(54) Title: COLOR DENSITY EXPOSURE CONTROL

(57) Abstract: The present invention provides methods and devices for using hue histograms to determine the appropriate color density adjustments for an image. The method comprises the steps of sampling color density values of an image, converting the color density values to hue values, categorizing the hue values into a number of discrete value ranges, aggregating the hue values within each discrete value range, and determining revised color density values based on the discrete value ranges and the aggregated hue values.

COLOR DENSITY EXPOSURE CONTROL

Field of Invention

The present invention relates to the field of
5   photography and videography. More particularly, the present
invention relates to improving the aesthetic appearance of
analogue and digital photographic and video images. More
particularly, the present invention relates to a method and
system for improving the color appearance of photographic
10   and video images.

Related Art

Color images captured in photographs or movies or
videos often require various color adjustments in order to
15   make them more aesthetically pleasing. Color adjustment may
be required to compensate for poor lighting or inappropriate
camera settings. However, color adjustments may also be
desired even when an image is accurately captured. For
example, fluorescent light has a blue-green color, and a
20   photograph of objects in a room lit with fluorescent light
will appear with a blue-green tint. Even though the
photograph accurately captures the image of a room with
fluorescent lighting, the image appears "incorrect." This
is because in a live setting, the brain automatically
25   "corrects" the colors of the images seen in a room with
fluorescent lighting. If an object is supposed to be white
in color, and it is well known that it should be white in
color, the brain will make it appear white by compensating
for the blue-green fluorescent lighting. Therefore, a
30   photograph of a room with fluorescent lighting must also be
adjusted to compensate for the blue-green color of the light
in order to capture the "correct" image.

In the past, an operator would have to manually adjust the color of each image until the images appeared pleasing to the eye. This required the operator to monitor each image being processed and, using the proper equipment,

5 manually change the color densities of each image until the image appeared aesthetically pleasing to the operator. This process is no longer used because of its numerous drawbacks. First, it is very costly and time consuming to have an operator stop an image processor, for printing photographs,

10 digitizing film, or some other processing step, in order to view an image and make changes to its appearance. Furthermore, it takes time and resources to train an operator, who must gain experience before being able to properly make adjustments to the image. Finally, subjective

15 judgments of image quality necessarily varies with different operators so that the value of having an operator manually adjust an image may be offset by inconsistencies in the final product.

There are various photographic printers that attempt to

20 automate the color adjustment process by using a plurality of color filters to detect various color density patterns in an image being processed and compare them to a database of color density patterns associated with specifically identified circumstances. With a plurality of filters,

25 these automated printers analyze the spectral distribution of a captured image and adjust the exposure level of the printed image to compensate for the situation identified. These printers, however, require the use of a large number of filters to analyze the many different colors in a

30 spectrum. Further, these devices have a finite database of color density patterns and are limited in their ability to identify and adjust to new or unanticipated situations, such as newly released film emulsions.

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There are also commercially available cameras that attempt to determine the type of lighting contained in an image before capturing the image. This process may be automatic or may have a manual switch for control by an
5   operator.

Conventional color and color density balancing in photographic printers and digital film scanners is done by using statistical values to set exposure levels or manipulate digitized data. For example, some devices
10   collect information concerning the color density of the colors red, green, and blue for a given number of pixels in an image and compute a histogram of densities for each color. These devices then match the constructed histograms with a database of known histograms and their associated
15   color adjustments and apply the appropriate color adjustments to the image being processed.

The drawback of the density histogram process is its limited ability to distinguish images with the same colors but different hues. This process can only determine how
20   much red, green, and blue is contained in each sampled image pixel, but cannot recognize the actual colors contained in the image. For example, the density histogram process cannot distinguish between an image of a room lit with blue-green fluorescent light and an image of a blue-green object
25   or even a scenic image of a blue sky and a green park. All of these images may have the same color densities, contain the same concentrations of red, green, and blue.

As a second example, a color density histogram of an image that is half green and half blue can look the same as
30   a histogram of a blue-green image because a measurement of color density is a measurement for specific colors, e.g., red, green, and blue. Determining the color densities for the colors blue and green will not determine the presence of

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the color blue-green. Therefore, attempting to determine
the contents of an image from a histogram of color densities
for a limited number of colors in that image may lead to an
incorrect result. The process may interpret an image of

5   blue sky and a green park to be a room using fluorescent
light and compensate by reducing the blue and green colors
of the resulting image.

For the foregoing reasons, there is a need for an
efficient and accurate method for determining the contents

10   of a captured image and adjusting the colors of that image
for a more aesthetically pleasing result.

Summary of the Invention

The present invention is directed to a method and

15   device for using color density values of an image to set the
parameters for capturing the image. In one aspect of the
invention, a method for determining color density values,
comprising the steps of sampling color density values of an
image, converting the color density values to hue values,

20   categorizing the hue values into a number of discrete value
ranges, aggregating the hue values within each discrete
value range, and determining revised color density values
based on the discrete value ranges and the aggregated hue
values, is provided.

25   In another aspect of the invention, color density
values of a plurality of colors are used to determine new
color density values.

In still another aspect of the invention, histograms of
the hue information are constructed from the color density

30   data obtained from an image.

In a further aspect of the invention, a neural network
uses a database of hue histograms to determine the
appropriate color density values for an image.

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In yet another aspect of the invention, computed color density values are used to process a photographic or digital image.

In another aspect of the invention, a color density determination system, comprising a means for converting color density values to hue values, a means for categorizing the hue values into a number of discrete value ranges, a means for aggregating the hue values within each discrete value range, and a means for determining revised color density values based on the discrete value ranges and the aggregated hue values, is provided.

In still another aspect of the invention, a color density determination system, comprising a scanner that samples color densities from an image and a computer system, with a memory that stores color density data, a converter that translates color density data into hue data, a histogram generator that categorizes the hue data, and a neural network that uses the categorized hue data to determine exposure time, is provided.

In yet another aspect of the invention, a computer program product, with sampling means for enabling a computer processor to sample color density values of an image, converting means for enabling the processor to convert the color density values to hue values, categorizing means for enabling the processor to categorize the hue values into a number of discrete value ranges, aggregating means for enabling the processor to aggregate the hue values within each value range, and determining means for enabling the processor to determine color density values based on the discrete value ranges and the aggregated hue values, is provided.

The present invention advantageously provides a novel method and system for creating improved photographic and video images.

Another advantage of the present invention is its

5   ability to produce photographic and video images that have aesthetically pleasing colors.

Yet another advantage of the present invention is an improved color density correction method.

A further advantage of the present invention is its

10   ability to adjust the colors of images illuminated by artificial light for more aesthetically pleasing appearance.

Still another advantage of the present invention is its computational efficiency and reduced data set.

Another advantage of the present invention is a

15   reduction in customer complaints regarding the appearance of printed film or digitally scanned images.

These and other features and advantages of the invention will be more fully understood from the following detailed description of a preferred embodiment that should

20   be read in light of the accompanying drawings.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and form a part of the specification, illustrate a

25   preferred embodiment of the present invention and, together with the description, serve to explain the principles of the invention.

FIG. 1 illustrates a flow diagram of a process of the present invention;

30   FIG. 2 illustrates sample color density plots of an image;

FIG. 3 illustrates a sample hue histogram of an image; and

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FIG. 4 illustrates an embodiment of the present invention.

Detailed Description

5   In describing a preferred embodiment of the invention, specific terminology will be used for the sake of clarity. However, the invention is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all equivalents.

10   The present invention is a novel method and system for optimizing the color density of photographic or video images in order to produce aesthetically pleasing images. In the field of photographic printing, the invention provides a method for determining exposure and illumination times. In

15   the field of film scanning and digitization, the invention determines the optimal parameters for exposing film to RGB (red-green-blue) light in order to capture digital film images. These parameters may include the duration and intensity of operation of the RGB lights and the shutter

20   speed of the sensors detecting the film image. The invention can also be used for adjusting the color and density of images previously stored in a computer program. It is a process for making images look more aesthetically pleasing.

25   Color density is a term known to those skilled in the art, and for an image, refers to a range of values. Although color densities can be measured for any color, in a preferred embodiment of the invention, color densities are measured for the colors red, green, and blue. Color and

30   density, as known in the art, refer to different characteristics. A black and white photograph has only one color with varying densities. Likewise, other images may contain the same color with different densities. For

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example, an image of an object in sunlight will have the same color as an image of the same object in the shade, but their color densities will be different. Thus, discussions of color densities of an image refer to ranges of densities

5   for different colors. The present invention helps to determine the ranges of RGB color densities that will make an image look better.

With reference to the drawings, in general, and FIGS. 1 through 4 in particular, the present invention is described.

10   FIG. 1 illustrates a flow diagram of a process of the present invention. Process 100 begins with step 110 wherein color density data is taken from an image being processed by the invention. The color densities of the image are sampled or measured at various points on the image. In a preferred

15   embodiment of the invention, densities are sampled for the colors red, green, and blue.

The sampling process can be performed with a single sensor or with a plurality of sensors. The image sampled may be a stored image, as in the case of processing

20   photographic film, or a live image, as in the case of a digital camera preparing to capture the image. A stored image may also be in a digital format contained in a digital image file.

Conventional sampling devices that may be used include

25   the Pre-scanner p/n66079627, available from Digital Now, Inc. of Vienna, VA, and the Kodak KLI-2113 tri-linear CCD sensor. The Pre-scanner p/n66079627 can sample the color densities of a photographic image to a pixel depth of 36 log bits. Conventional video cameras, such as the 3-chip color

30   video camera model X0003 manufactured by Sony, may also be used to perform the sampling function as is known in the art.

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Many conventional color correction systems process the sampled color density data to calculate various statistical measures such as means, medians, and standard deviation. These conventional systems then use the statistical color

5   density profiles to determine the adjustments to be made to an image based on a database of other known color density profiles. The drawback of this process is the limited information contained in color density data. For example, the color density profiles of an image that is half blue and

10   half green will resemble the color density profile of a blue-green image.

In the present invention, step 120 translates the color density data into hue data. It would be readily apparent to one skilled in the art how to convert color density data to

15   hue data. An explanation of the process of converting color density data to hue data can be found on page 50 of the book entitled Video Demystified, written by Keith Jack and published by HighText Publications, which is incorporated herein by reference.

20   In a preferred embodiment of the invention, the hue data is measured units of degrees of rotation around a hue circle, which represents the various wavelengths along the color spectrum. Each sampled pixel of an image produces color density data that is translated into a hue data point.

25   The translation process converts the density data of a selected number of colors to hue data that represents all the different colors contained in the sampled image. Hue data is obtained in this manner because it is impractical to sample an image for all the colors in the visible spectrum

30   whereas the color density data for a small number of colors would contain the same hue data.

In step 130, the hue data is grouped into discrete ranges or "bins" of degrees of rotation around a hue circle.

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The number of bins is a function of the number of points
sampled on the image being processed and thus the number hue
data points. In one embodiment of the invention, the number
of bins is equal to the square root of the number of hue
5   data points. The quantity of hue data points in each bin is
then aggregated. In this manner, step 130 constructs a
histogram of the hue data points. Entire images are thus
represented by hue histograms.

In step 135, a hue histogram is compared to a database
10   of hue histograms. The hue histograms in the database are
constructed from the raw color density data sampled from
known images. The hue histogram database is also linked to
a corresponding set of adjusted color densities for each
image represented by a hue histogram. The set of adjusted
15   color densities is constructed by an operator who manually
adjusts the raw color density measurements of each image in
the database for aesthetic quality. The color density
adjustments can also be made using a fixed algorithm or
other methods known in the art. The color density
20   adjustments for each image are then stored in the database
and are linked to the hue histograms of their respective
images. The database thus serves as a look-up table of
adjustment values. A hue histogram of a sampled image is
matched to a hue histogram in the database, and the
25   corresponding color density adjustments are retrieved from
the database and applied to the sampled image.

In a preferred embodiment of the present invention, an
artificial neural network performs step 135. In this
embodiment of the invention, an operator is initially needed
30   to train the neural network by building the hue histogram
database. The operator analyzes the color quality of a
sufficient number of images to cover a cross-section of all
possible images and determines the proper color density

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adjustments for each image. In a preferred embodiment of
the invention, the operator determines the proper color
density adjustments for the colors red, green, and blue. In
a preferred embodiment of the invention, the color density
5   adjustments are parameters for capturing the image in a
separate medium comprising a combination of illumination
intensity and duration, and exposure time. These
adjustments, along with the hue histogram of the
corresponding image, are stored in the database. This
10   process creates a training set for the supervised training
of the neural network.

In a preferred embodiment of the invention, the
training set contains at least 100 sample histograms and
corresponding color density adjustments for each histogram
15   bin created by step 130. For example, if a color density
sampling device samples 924 pixels on an image, then
according to one preferred embodiment of the invention,
there would be approximately 31, the square root of 924
rounded up, hue histogram bins to categorize the resulting
20   hue data. Thus for the preferred embodiment, a
representative population of 31 x 100, or 3100, real world
images would be required to comprise the training set for
the neural network.

In a preferred embodiment of the invention, this
25   database or training set defines the input and output
variables to be applied to a commercially available neural
network software package. In a preferred embodiment of the
invention, the input variables comprise the array of numbers
representing the population of data points in each of the 31
30   histogram bins generated by step 130, and the output
variables comprise color density adjustment values for the
colors red, green, and blue.

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The neural network software then analyzes the training
set to derive an algorithm for processing the hue histogram
of a sampled image and producing appropriate color density
adjustments. Methods for training neural networks are known
5   in the art and include the back-propagation of errors
method, the fast-prop method, multi-layer perceptron, and
radial basis functions. Any type of learning system can be
utilized. In one embodiment of the invention, Trajan™
neural network software, available from Trajan Software,
10   LTD., London, UK, is used.

The neural network training sets would be altered for
different applications because the output variables may be
different. For example, the process of digitizing film
images would require outputs that set the parameters for
15   illuminating the film and exposing sensors to the
illuminated image. On the other hand, the process of
capturing an image with a digital camera would require
outputs in the form of aperture and shutter speed settings.
It would be apparent to one skilled in the art what output
20   variables are needed for different applications.

The neural network described operates with a fixed
training set and a fixed algorithm for computing color
density adjustments. However, as known to those skilled in
the art, a neural network with a continuously expanding
25   training set that learns with each hue histogram processed
can be used.

Step 140 applies the color density adjustments to the
sampled image to create an enhanced image. The application
of color density adjustments may be in conjunction with
30   capturing the sampled image in a separate medium, as with
the digitization of film. The adjustments may also be
applied to the original image.

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Step 150 is an optional step for evaluating the quality
of the color density adjustments. If the adjustments
produce a poor quality image, process 100 would be repeated
until a successive iteration produces an acceptable image.
5   The number of iterations would be limited to a practical
number. When process 100 produces an acceptable image, the
process is complete. Step 150 may be omitted when cost and
efficiency considerations supercede.

FIG. 2 illustrates sample blue, green, and red
10   histogram plots of the color densities of an image of a
blue-green painting exposed to fluorescent light. In FIG.
2, the Y-axis measures the frequency of occurrence, and the
X-axis specifies the density ranges or bins. Histograms are
often shown as jagged bar graphs instead of a continuous
15   curve because of the limited and finite number of bins used
for aggregating the sampled data points.

Because the fluorescent lighting is also blue-green in
color, the densities of the image are enhanced for the
colors green and blue. The plots show that, for this
20   situation, it may not be possible to determine from color
density information whether the image merely contains a
blue-green painting or contains blue-green fluorescent
lighting. The inability to make such a determination in
this or other situations limit the usefulness of using color
25   density data to perform color density adjustments.

FIG. 3 illustrates a sample hue histogram of the same
image used in FIG. 2. As in FIG. 2, the Y-axis measures the
frequency of occurrence, and the X-axis specifies the bins,
measured in degrees of the hue circle, of the hue colors
30   measured. A hue histogram can identify the specific color
wavelength characteristic of blue-green fluorescent light
and thus can distinguish between an image that should be
adjusted to compensate for fluorescent lighting and an image

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containing a lot of blues and greens, like a photograph of
an outdoor park taken in daylight, for example.

FIG. 4 illustrates one embodiment of a system of the
present invention. In this embodiment, devices 410 and 440
5   digitize film images. Using device 410, film 405 is
advanced from reel 415 to reel 435. While film 405 is being
advanced, it passes sensor 420, which samples the color
densities of each film frame. In a preferred embodiment,
sensor 420 is the pre-scanner device disclosed and described
10   in co-pending U.S. patent application No. _____,
(attorney docket number 26183.1004-US01, filed August 17,
2000, entitled "Film Density Scanner,", of which William G.
Reed and John O. Renn are the inventors, the entirety of
which is incorporated herein by reference. In a preferred
15   embodiment, device 410 is the ExpressScan-4B™, available
from Digital Now, Inc. of Vienna, VA. In a preferred
embodiment, sensor 420 scans film 405 with RGB LEDs to
obtain RGB color density data.

The sampled color density information is transferred to
20   device 440, via data link 439. Device 440 is a computer
processing system such as a commercially available computer
device, with monitor 481, mouse 482, and keyboard 483. The
color density data is stored in memory 445, which can be
random access memory. The color density information is then
25   converted to hue data by converter 450. The hue data is
then used to construct a hue histogram by generator 455.
The generated hue histogram is then analyzed by neural
network 460. In a preferred embodiment of the invention,
converter 450, generator 455, and neural network 460 are
30   each components of a single software program. In a
different preferred embodiment, those devices are components
of a computer hardware processor. In a preferred
embodiment, neural network 460 uses the Trajan™ neural

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network software, available from Trajan Software, LTD.
London, UK, or another functionally similar program.

The color density adjustments determined by neural
network 460 are sent back to device 410 via data link 461.
5   In a preferred embodiment the color density adjustments are
parameters for operating sensor 425 and light source 430 in
order to illuminate film 405 and capture a film image with
the desired color densities based on the color density
adjustments. The parameters may include illumination
10 duration and intensity for light source 430 and aperture and
shutter speed setting for sensor 425. In a preferred
embodiment, light source 430 comprises RGB LEDs. In a
preferred embodiment, sensor 425 is a Thomson™ digital
camera, available from Thomson CFS, Orsey, Cedex, France.
15 The digitized image is then sent from sensor 425 to
frame grabber 470 via data link 426. In a preferred
embodiment, frame grabber 470 is a Thomson™ frame grabber.
The digital image can then be stored as a digital file in
memory 480 or external memory 490, or sent to computer
20 network 495.

While there have been shown and described specific
embodiments of the present invention, it should be apparent
to those skilled in the art that various changes and
modifications may be made without departing from the scope
25 of the invention or its equivalents. The invention is
intended to be broadly protected consistent with the spirit
and scope of the appended claims.

What is claimed is:

1.   A method of determining color density values comprising the steps of:

sampling color density values of an image;

5   converting the color density values to hue values;

categorizing the hue values into a number of discrete value ranges;

aggregating the hue values within each discrete value range; and

10   determining revised color density values based on the discrete value ranges and the aggregated hue values.

2.   The method of claim 1 wherein the sampling step comprises sampling the color density values of at least

15   three colors.

3.   The method of claim 2 wherein the three colors are red, green, and blue.

20   4.   The method of claim 1 wherein the sampling step is carried out using a video or still camera.

5.   The method of claim 1 wherein the image is an image stored in a medium.

25

6.   The method of claim 1 wherein the determining step is carried out manually.

7.   The method of claim 1 wherein the determining step is

30   carried out using a predetermined algorithm.

8.   The method of claim 1 wherein the determining step is carried out using a neural network.

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9. The method of claim 1 wherein the determining step comprises comparing the aggregated hue values with a set of aggregated hue values stored in a memory area.

5

10. The method of claim 1 wherein the determining step is carried out for each color density value sampled in the sampling step.

10   11. The method of claim 1 wherein the number of discrete value ranges is a function of a number of color density values sampled in the sampling step.

12. The method of claim 11 wherein the number of discrete
15   value ranges is less than or equal to the number of color density values sampled.

13. The method of claim 11 wherein the number of discrete value ranges is a square root of the number of color density
20   values sampled.

14. The method of claim 1 further comprising the step of creating a histogram based on the hue values and the number of discrete value ranges.

25

15. The method of claim 1 further comprising the step of adjusting the image based on the revised color density values.

30   16. The method of claim 1 further comprising the step of recording the image based on the revised color density values.

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17.   The method of claim 16 wherein the recording step
comprises computing a shutter exposure time.

18. The method of claim 16 wherein the recording step
comprises computing times for illuminating the image.

19.   The method of claim 18 further comprising the step
illuminating the image with a red, green, or blue light for
the computed times.

20.   The method of claim 19 wherein the red, green, and blue
lights are LED lights.

21.   A color density determination system comprising:
      -     a means for converting color density values to hue
values;
      a means for categorizing the hue values into a number
of discrete value ranges;
      a means for aggregating the hue values within each
discrete value range; and
      a means for determining revised color density values
based on the discrete value ranges and the aggregated hue
values.

22.   The system of claim 21 wherein the converting means
comprises a color space converter.

23.   The system of claim 21 further comprising a means for
sampling color density values of images.

24.   An exposure determination system comprising:
      a scanner that samples color densities of images; and

a computer system configured to determine exposure
times based on sampled color densities.

25.   The system of claim 24 wherein the computer system
comprises:
        memory that stores color density data;
        a converter that translates color density data into hue
data;
        a histogram generator that categorizes the hue data;
and
        a neural network that uses the categorized hue data to
determine exposure times.

26.   The system of claim 25 wherein the computer system
further comprises a frame grabber that captures the image.

27.   The system of claim 24 further comprising an
illumination source to illuminate the image based on the
exposure times.

28.   An exposure determination system comprising:
        a memory device having embodied therein color density
data; and
        a processor in communication with said memory device,
said processor configured for
                converting color density data into hue data,
                categorizing the hue data, and
                determining exposure times from the categorized
hue data.

29.   A computer program product comprising a computer usable
medium having computer program logic recorded thereon for
enabling a processor in a computer system to facilitate

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determining color density values, said computer program
logic comprising:

sampling means for enabling the processor to sample
color density values of an image;

5   converting means for enabling the processor to convert
the color density values to hue values;

categorizing means for enabling the processor to
categorize the hue values into a number of discrete value
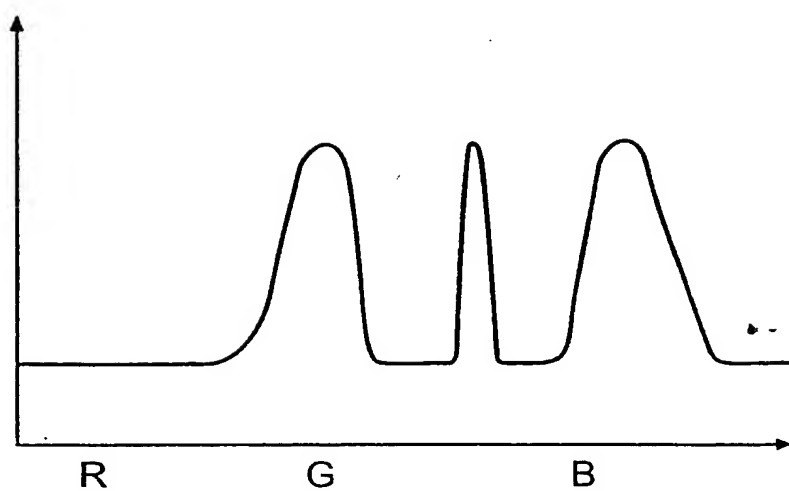ranges;

10   aggregating means for enabling the processor to
aggregate the hue values within each value range; and

determining means for enabling the processor to
determine color density values based on the discrete value
ranges and the aggregated hue values.

FIG. 1

NSDOCID: <WO___ __0115409A2_I_>

FIG. 2

FIG. 3

FIG. 4

(54) Title: COLOR DENSITY EXPOSURE CONTROL

(57) Abstract: A methods and devices for using hue histograms to determine the appropriate color density adjustments for an image. The method includes the steps of sampling color density values of an image (110) converting the color density values to hue values (120), categorizing the hue values into a number of discrete value ranges (130), aggregating the hue values within each discrete value range, and determining revised color density values based on the discrete value ranges and the aggregated hue values (135).

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :HO4N 3/14

US CL : 348/272
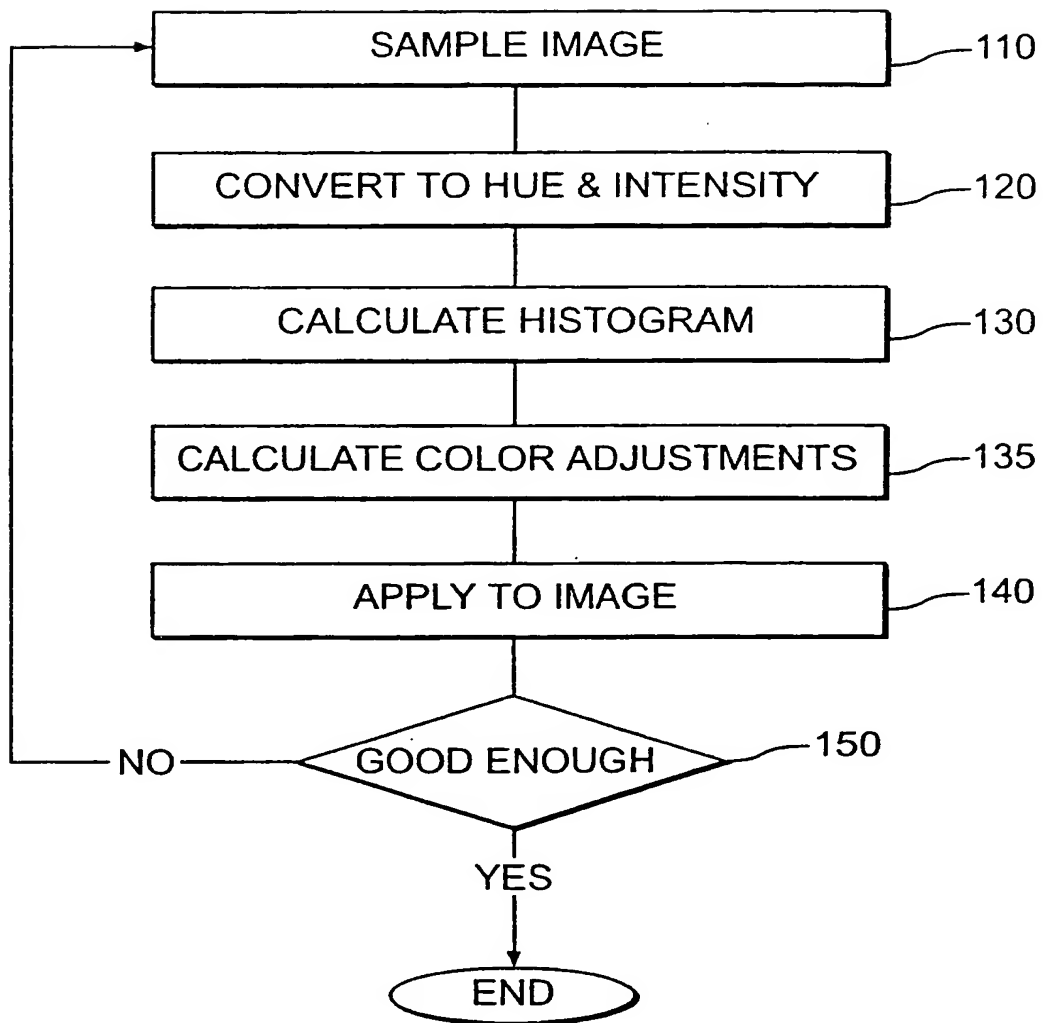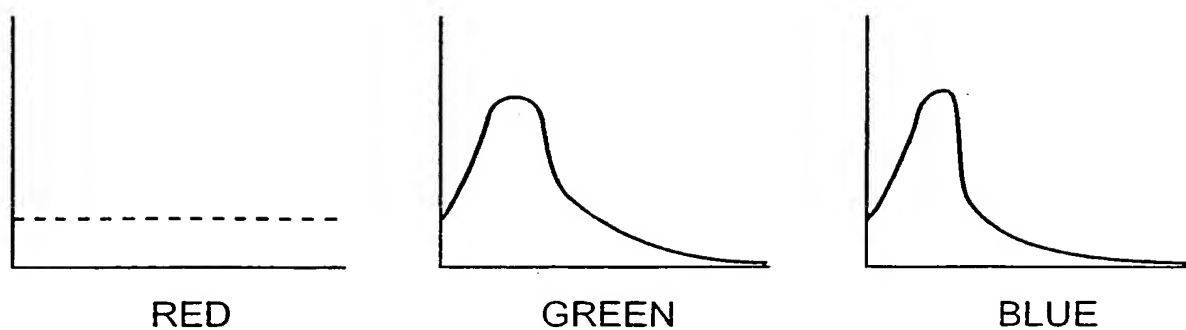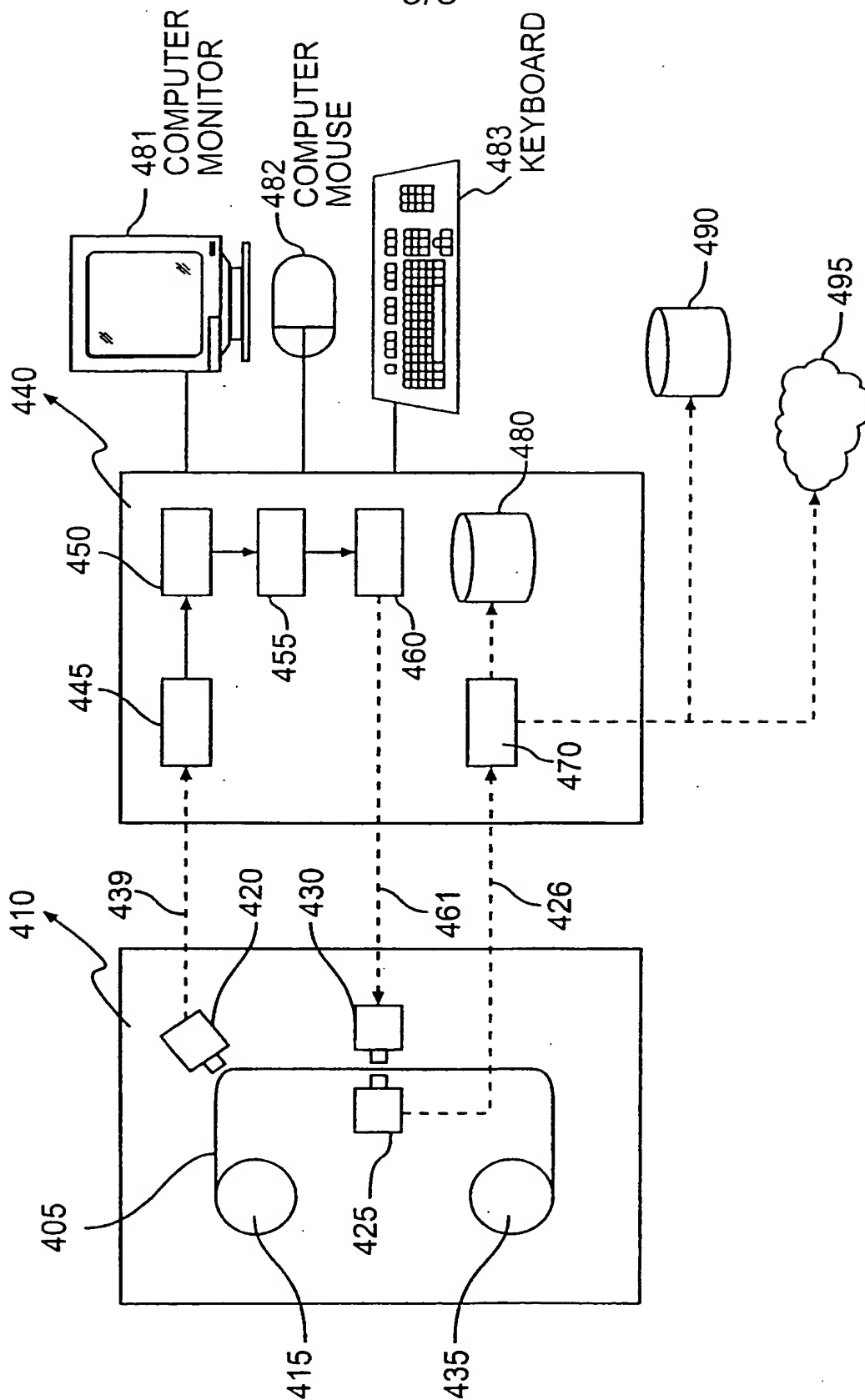
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 348/272

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST, WEST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

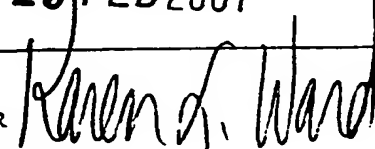| Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,408,343 A (SUGIURA et al) 18 April 1995, see Figs. 3-11, col. 3, lines 40-col. 4, lines 65+.	1-24, 27, and 29
Y	US 4,929,978 A (KANAMORI et al) 29 May 1990, Figs. 1-13, col. 6, line 5-col. 7, line 55+.	1-24, 27 and 29
Y	US 5,109,275 A (NAKA et al) 28 April 1992, Figs. 1-6, col. 7, lines 5+.	8, 25
Y	US 5,416,848 A (YOUNG) 16 May 1995, Fig. 1, col. 6, lines 45+.	26
X	US 5,822,453 A (LEE et al) 13 October 1998, Figs. 1-10, col. 4, line 5-col. 6, lines 55.	24
X	US 5,309,228 A (NAKAMURA) 03 May, 1994, Figs. 1-11, col. 11, line 5-col. 14, line 40+.	28

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

*	Special categories of cited documents.	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance		
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
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Date of the actual completion of the international search	Date of mailing of the international search report
13 DECEMBER 2000	15 FEB 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer WENDY GARBER Telephone No. (703) 305-4929

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.